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# BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

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No. 380

## SPECTROPHOTOELECTRIC SENSITIVITY OF THALOFIDE

BY

W. W. COBLENTZ, Physicist  
*Bureau of Standards*

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JUNE 17, 1920



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# SPECTROPHOTOELECTRIC SENSITIVITY OF THALOFIDE

By W. W. Coblentz

## 1. INTRODUCTION

Thalofide is a laboratory preparation of thallium-oxy-sulfid which was discovered by T. W. Case<sup>1</sup> to be photoelectrically sensitive. The material, after careful preparation, is fused upon a disk of quartz about 2 cm in diameter, and placed in an evacuated glass tube. The sensitivity is greatly increased in a vacuum, which preserves the life of the material by preventing oxidation.

The material seems to undergo a slow photochemical change (decrease in resistance), when exposed to blue and violet light, and hence it is mounted in an evacuated bulb of red glass.

The first sample examined<sup>2</sup> was purchased from Mr. Case. It was in a red glass bulb, and was marked "Type RL, No. 29." On communicating the results to Mr. Case, he generously offered to send another sample, which was mounted in an evacuated bulb of clear glass. This cell, No. 717, was several years old and had decreased somewhat in sensitivity. An empty red glass bulb was sent. By determining its spectral transmission it was possible to correct for the absorption of radiation by the red glass bulb which inclosed sample No. 29.

The experimental procedure was the same as in previous work,<sup>3</sup> except that a quartz prism was used for dispersing the radiation from the gas-filled tungsten lamp which was used for producing an equal energy spectrum.

In order not to injure the cell by exposure to strong daylight, it was placed in a suitable light-tight, tubular mounting (with a shutter), which could be slipped into the permanent ways which support the thermopile before the spectrometer slit.<sup>4</sup> Subse-

<sup>1</sup> Case Research Lab., Auburn, N. Y. See Phys. Rev., (2), 15, p. 289, 1920; also U. S. patents Nos. 1 301 227 and 1 316 350 for a light-reactive resistance.

<sup>2</sup> Coblentz, Phys. Rev., 15, p. 139, 1920. Amer. Phys. Soc.; Nov. 28, 1919.

<sup>3</sup> B. S. Bulletin, 15, p. 121, 1919.

<sup>4</sup> B. S. Bulletin, 11, p. 132 (Fig. 3); 1914.

quently, for testing the effect of temperature, this mounting was modified by surrounding it with a small tin box, which could be filled with ice or water. The data presented herewith therefore represent two series of experiments in which the photoelectric cell had been remounted and, hence, the same parts of the photoelectric material were probably not examined each time. Moreover, since the cells were mounted directly at the exit slit, and 2 to 3 cm back of it, a wide portion of the photosensitive material was exposed to the radiation stimulus.

In these tests the thalofide cell, which has a resistance of several megohms, was placed in series with a dry battery, a high-resistance, and a short-period d'Arsonval galvanometer.

In view of its high sensitivity this device should be found useful in certain laboratory measurements and in measuring variable stars, etc. Its sensitivity is affected by change in temperature, hence for stellar radiation work it would have to be operated in a thermostat.

In common with all selective radiometers, it is quite impractical to specify the radiation sensitivity of the thalofide cell in terms of heterochromatic radiation, such as the visual rays from a tungsten lamp. It is very interesting to find that this new substance lowers its electrical resistance by 100 per cent on exposure to less than 0.1 m candle, using a tungsten filament. However, it should be remembered that this cell has its maximum sensitivity at  $1\mu$ , where occurs the maximum emission of the tungsten lamp, so that the sensitivity test is principally for radiations at 0.9 to  $1.2\mu$ . On the other hand, selenium is quite insensitive to these radiations, but has its maximum sensitivity at  $0.7\mu$ , where the tungsten lamp is weak in radiation. Hence, no accurate comparison of the sensitivity of these two light-reactive substances is possible. However, speaking in general terms, this substance is very sensitive to the infra-red, just as the potassium hydride gas-ionic photoelectric cell is very sensitive to the violet rays

By placing an absorption screen (say, of deep red glass and a water cell) in front of the cell, so as to obtain a fairly narrow spectral band of radiation at  $0.9\mu$ , and testing the sensitivity with a standard lamp (say, a vacuum tungsten lamp), it may be possible to standardize the device for precise measurements. The cells examined were far more steady and reliable in action than selenium.



## 2. EXPERIMENTAL DATA

The spectrophotoelectric sensitivity of thalofide is illustrated in Fig. 1, in which curve *B* shows the behavior of sample No. 717, which was in the clear glass bulb. Curve *A*, Fig. 1, shows the behavior of sample No. 29 (on 12 volts; dark current = 3 cm), after correcting for absorption of the red glass bulb. Further observations, uncorrected for absorption of the red glass bulb, are illustrated in Fig. 3.

The two samples have practically the same spectrophotoelectric sensitivity, which consists of a complex, unsymmetrical band, with maxima in the region of 0.9 and  $1\mu$ . The sensitivity curve of thalofide is remarkable for the abruptness with which it terminates

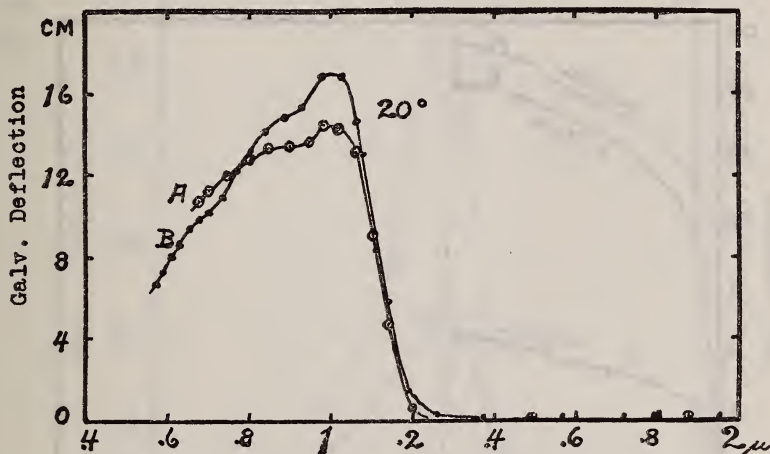


FIG. 1.—Spectrophotoelectrical sensitivity curves of thalofide

at  $1.2\mu$ , beyond which point this substance appears to be insensitive photoelectrically.

For the intensities used, sample No. 29 seemed to fatigue a little in the course of an hour's work.

**RESPONSIVE-TIME CURVES.**—The method of observation is to expose the sample to radiation and to read the galvanometer deflection at short intervals. In Fig. 2 is shown the increase in the photoelectric current (galvanometer deflection) with time of exposure to radiation. The dotted parts of these curves illustrate the recovery of the cell after exposure to radiation.

This substance is remarkable for its quickness of response, which is quite complete after a lapse of 15 seconds. On still longer exposure the galvanometer deflection increases slowly, and sometimes irregularly, as indicated by the discontinuity in the curves in Fig. 2. Such an irregular increase in conductivity was noticed previously in molybdenite.

While the time (two minutes) to attain a maximum response was shorter than that of molybdenite, this substance behaves somewhat like it in requiring twice as long (four minutes) for complete recovery. For small deflections, an exposure of one minute, with two minutes for recovery, was sufficient.

Fig. 2, curve A, illustrates the response of thalofide cell No. 717, and curves B and C illustrate the response of cell No. 29.

EFFECT OF TEMPERATURE.—It was of interest to determine the effect of temperature upon the spectrophotoelectric sensitivity. For this purpose the cell was placed in a bath of ice, as already described. Since the thalofide tube was not directly in contact with the ice (or hot water), the photosensitive material was

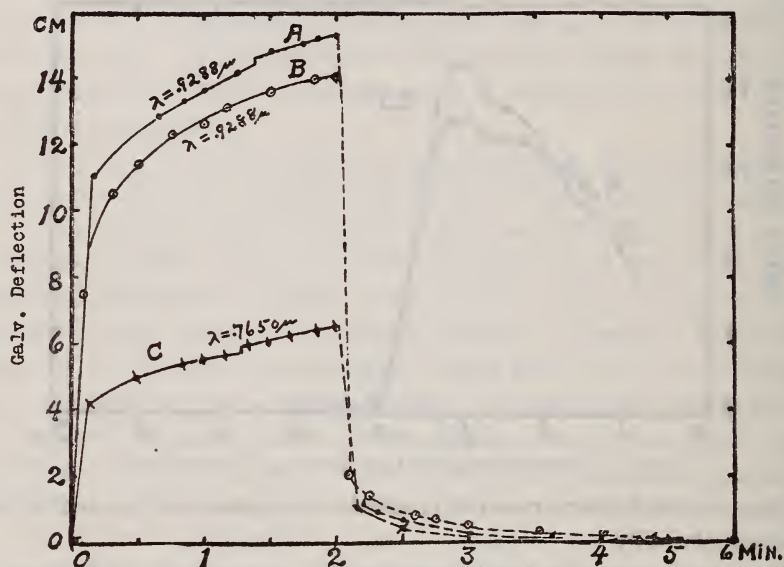


FIG. 2.—Variation of photoelectrical current with time of exposure to radiation

probably not cooled to  $0^{\circ}\text{C}$ , though for convenience that temperature is used.

In Fig. 3 the effect of temperature upon thalofide cell No. 29 is illustrated. These curves are not corrected for absorption of radiation by the red glass bulb. Furthermore, they are for the cell remounted in the holder, as already mentioned. The applied potential (12 volts) was kept constant, and at room temperature ( $18^{\circ}\text{C}$ ) the dark current was 1.6 cm, while at  $0^{\circ}\text{C}$  the dark current was only 7 to 8 mm.

Nevertheless, keeping the radiation intensity constant, at  $0^{\circ}\text{C}$  the photoelectric sensitivity (current) is about three times as

large as that obtained at  $18^{\circ}\text{C}$ . Since at a given temperature the photoelectric current is proportional to the dark current, as observed on actual test, if we had raised the voltage sufficiently to produce a dark current of 1.6 cm, the photoelectric current at  $0^{\circ}\text{C}$ , for radiation of wave length  $\lambda = 1\mu$ , would have been about six times that obtained at  $18^{\circ}\text{C}$ .

In Fig. 4 is shown the effect of temperature upon thalofide cell No. 717. At room temperature ( $16^{\circ}\text{C}$ ) the dark current was 2.6 cm on about 30 volts. At  $0^{\circ}\text{C}$  the applied potential was about 50 volts, producing a dark current of 2.2 cm. At  $35^{\circ}\text{C}$

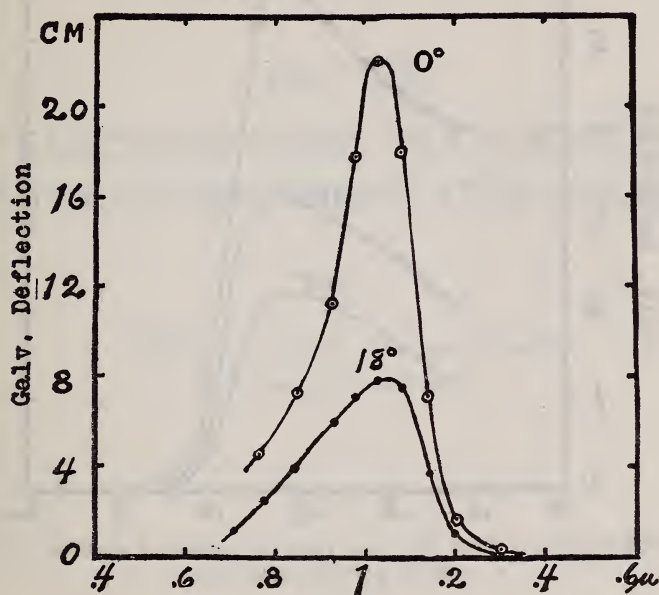


FIG. 3.—Effect of temperature upon the spectrophotoelectrical sensitivity of thalofide cell No. 29 (red glass bulb)

the dark current through the cell, on 20 volts, was 5.9 cm. Nevertheless, the maximum (photoelectric) galvanometer deflection was only 2.1 cm. If the dark current had been reduced to 2.6 cm, the maximum deflection, at  $35^{\circ}\text{C}$ , would have been only about 0.9 cm, as compared with 5.8 cm observed at  $0^{\circ}\text{C}$ .

The curves illustrated in Fig. 4 show that, in common with nearly all photoelectric substances examined, the sensitivity increases the most rapidly on the short wave-length side of the maximum, and the maximum of the sensitivity curve shifts toward the short wave lengths, with decrease in temperature.



## 3. SUMMARY

Experimental data are given on the spectrophotoelectric sensitivity of Case's preparation of thallium-oxy-sulfid, thalofide, when exposed to thermal radiation of wave lengths extending from  $0.58$  to  $3\mu$ .

It was found that this substance has a wide, unsymmetrical, complex band of photoelectric sensitivity, which extends from the visible into the infra-red, where it terminates abruptly at  $1.2\mu$ .

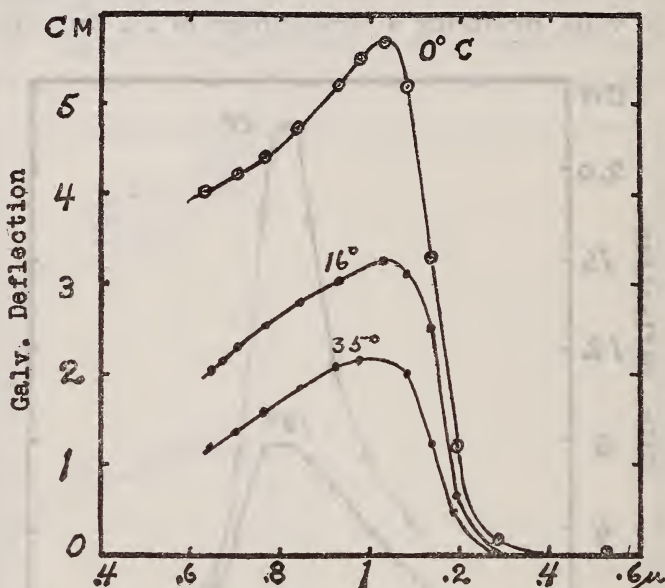


FIG. 4.—Effect of temperature upon the spectrophotoelectrical sensitivity of thalofide cell No. 717 (clear glass bulb)

There is a maximum at  $1\mu$  and probably a smaller maximum at  $0.85\mu$ .

The effect of temperature, from  $0$  to  $35^{\circ}\text{C}$ , was investigated. It was found that, in common with nearly all photoelectric substances thus far examined, the sensitivity increases the most rapidly on the short wave-length side of the maximum, and the maximum of the sensitivity curve shifts toward the short wave lengths, with decrease in temperature.

WASHINGTON, January 3, 1920.



